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Dandak: a mammalian dominated cave ecosystem of India

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ABSTRACT

Perpetual darkness, high humidity with almost constant geophysical factors are some of the abiotic factors which make the cave ecosystem unique. For any species a high degree of adaptation is always needed to thrive in such an ecosystem. Mammals in general have never adapted to cave life but they can play a major role in the cave ecosystem. Structurally, the Dandak cave has two distinct chambers that are completely different from each other in several geophysical factors. Thus both the cave chambers offer two distinct types of ecological niche. In the present study we found that both chambers of this cave were dominated by mammals all year round. Additionally, the group of mammals using the outer chamber completely differs from the group using the inner one. Possible geophysical factors responsible for such differences are discussed.

Key words: cavernicoles, cave ecosystem, troglophiles, mammals, carnivores

INTRODUCTION

Subterranean habitats are always unusual and fascinating. These ecosystems are characterized by perpetual darkness, constant temperature and high humidity with limited air currents, which altogether creates an ecosystem that is difficult to support the organisms adapted to normal surface conditions. Nevertheless, some organisms are attracted to live in caves at least for part of their life cycle due to low predation pressure, easy availability of prey and less risk from natural calamities along with some of the typical geophysical factors mentioned above. Cave dwelling/adapted organisms are generally evolved from such epigean forms which had some degree of preadaptation for a hypogean lifestyle prior to invasion for cave life (Racovitza 1907; Vandel 1965; Gunn 2004). Cave dwelling organisms can be broadly divided into two categories: an organism once trapped accidentally or get intentionally inside a cave, and unable to survive in an external epigean environment is referred as an obligatory cave dwelling organism—stygobionts (aquatic) and troglobionts (terrestrial). On the other hand, organisms that use caves for a short period either for shelter, feeding, breeding, roosting, hibernating etc. but depend mostly on the external epigean environment can be referred as non-obligate cave dwellers. Further, ecologically several classifications have been forwarded to classify the cavernicoles, which are based on their respective level of bondage to the cave life. However, as per the most recent classification proposed by Sket (2008) the cavernicoles have been categorized into four types: troglobites, eutroglophiles, subtroglophiles and trogloxene. In the present work the same classification has been adopted to interpret the cavernicolous status of the organisms observed in Dandak Cave as the same was utilized by Biswas (2010) while describing the fauna of its adjacent cave "Kotumsar" of Kanger Valley National Park, India.

Dandak cave of Kanger Valley National Park was initially discovered in 1995 by the forest staff of the National Park while chasing some of the local tribes that had been illegally hunting the Indian (crested) porcupine (*Hystrix indica)*. The episode ended as the porcupine entered a deep tunnel that turned out to be the entrance of Dandak cave. Since the cave discovery several construction projects have been undertaken inside the cave to make the cave more accessible for tourism. However in order to reach this particular cave of Kanger Valley National Park one has to climb at least 450 stairs, and due to this specific reason the tourists generally avoid it. At the present time the cave is not open for general tourism; special permission is required to enter. It is apparent that the ecosystem of this cave is not under high anthropogenic pressure, and to a large extent its inner ecosystem is still left in its *in situ* condition.

Dandak is a limestone cave (18º51'30" N; 81º57'00" E) situated on the top of an isolated hillock exhibiting a few patches of exposed boulders. The cave opens at the base of a rock wall situated in a north-west direction. The cave entrance is wide and opens up horizontally into a large hall; the outer chamber (Fig. 1). Despite a few side passages and downward sloping passages the approximate length of this cave is only 360m. Structurally this cave is divided into two main chambers connected with each other by two small convoluted narrow passages. Due to its wide entrance, the external light penetrates to the far end of the outer chamber, which possesses massive and beautiful dripstone structures. Some of the stalagmites and stalactites have joined each other forming

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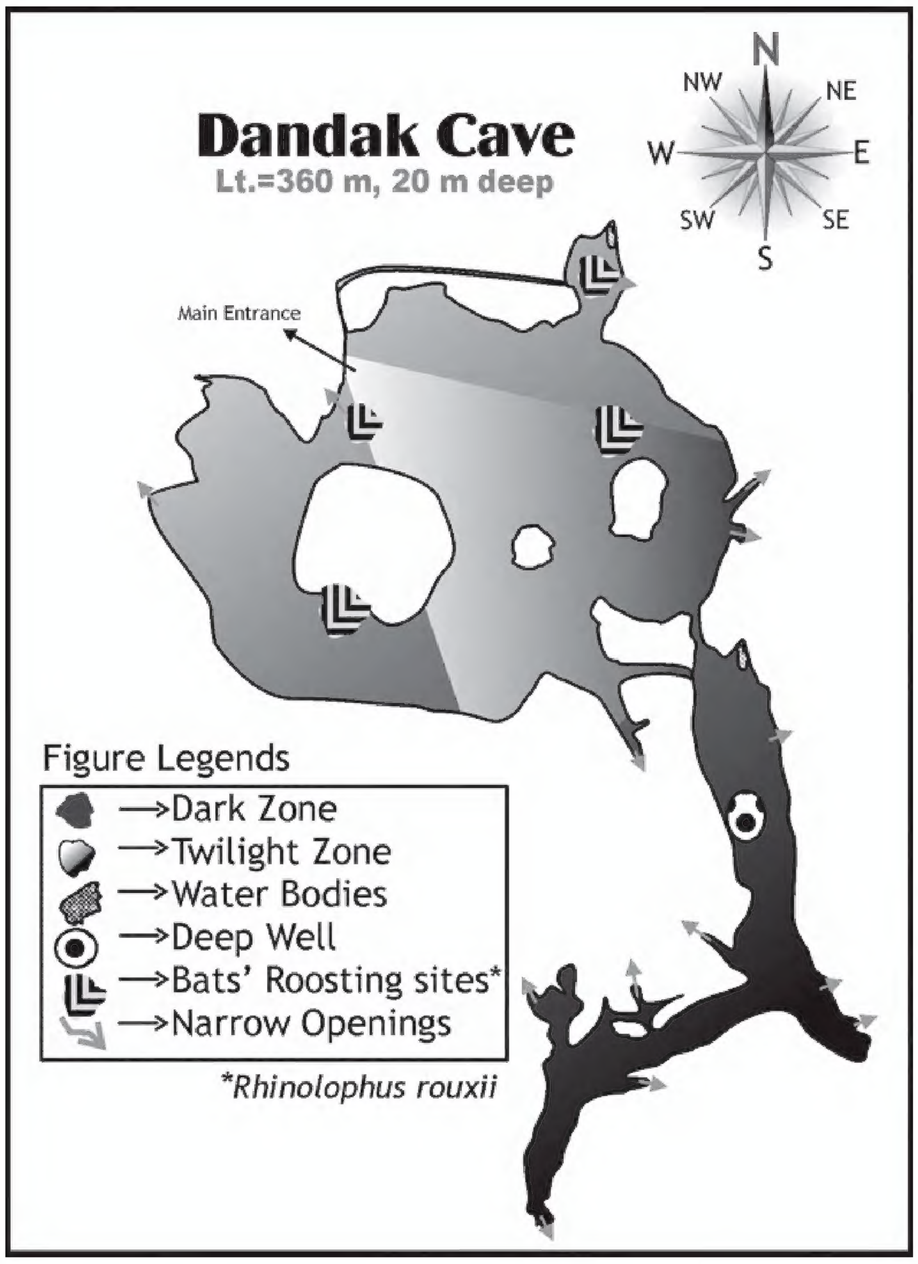

Fig. 1 - Schematic layout of Dandak Cave, showing both the chambers connected with each other by two narrow passages. Figure is also representing the luminous factors existing inside each chamber.

columns. The inner chamber is configured more like a tunnel with an unexplored deep well-like vertical pit near its entrance. In this cave, the major portion of the outer chamber can be safely referred as "twilight zone" whereas the inner chamber represents a "deep zone" cave environment. It appears that in this cave, the "intermediate/ transition zone" is almost absent and the existence of real "stagnant zone" is yet to be explored, if any; inside the well (Vermeulen and Whitten 1999; Biswas 2009, 2010).

OBJECTIVES AND METHODS

This study is intended to understand the biodiversity together with obtaining preliminary ideas about the ecosystem operating inside the cave. The study is based on qualitative collections and ecological field records that are in turn based on the direct or indirect evidence of animals making use of this cave. In the first phase of this study a tentative layout of the cave was drawn by mapping it with the help of measuring tape and compass. We noted all the possible openings and blow holes on the map where the cave connects to the outer surface. We carefully surveyed the entire cave that includes recognizing and noting all sorts of small and spacious habitats which could be used by any animal / organism. The survey included the locations, where drip water accumulates as well. In addition, several geophysical parameters viz; atmospheric temperature, humidity, water temperature and its pH value were also measured during dry (May) and wet (September) seasons in the field by using digital thermo-hyrometer (Pacer® TH 402) and pH meter.

The observations were made at every second month through a span of one year and in each field visit every nook and cranny of the cave was carefully observed to document the direct /indirect evidence(s) of any animal which used the cave for any purpose. Evidences were photographed and also other scientific techniques were employed to determine the animal species. Help from local tribes were taken to confirm the existence of suspected animals. We also attempted to determine the role of each visitor and/ or permanent inhabitants inside the cave, in their particular zone of occurrence. A speculative food pyramid has been constructed that may be operating within the cave (Fig. 4).

OBSERVATION AND RESULTS

A tentative map of the cave is shown in Figure 1 and which has been described in the earlier part. The geophysical factors between the two chambers apparently differ from each other while compared between dry and wet season (Fig. 2). We observed that rain water enters the cave mainly through the main entrance of the outer chamber which finally drained out via the deep well existing in the inner chamber. No standing water is apparent inside any chamber of this cave. However, few very small water pockets are present in both the cave chambers, fed by seepage which have almost constant temperature (18.0 – 20.0^{0}C) pH values (7.2-7.5) throughout last year. These are presumably with epikarst water fed small pools (Pipan 2005).

Though the major portion of the outer chamber of the cave is mostly lit during the day time, the organisms we observed here are mostly trogloxene. Nevertheless, the organisms we observed in the inner chamber represent all the categories of cavernicoles. Species inhabiting and/or approaching regularly in both the chambers are described here.

Vertebrates:

Chiroptera, Rhinolophidae
Rhinolophus rouxii Temminck, 1835
(Fig. 3a)

Common name: Rufous Horseshoe bat.

A small colony of about 50-60 individuals roost in the outer chamber of Dandak Cave. We marked 4-5 different locations (small habitats) which are from time to time used by this colony. Roosting sites could be easily recognized by seeing the decomposed deposits of guano piles in the

floor (Fig. 3b). Occasionally a few solitary bats were also apparent in some of the hidden cavities of this chamber. Observed evidence supports that this particular bat remains under predation pressure in this cave (Fig. 3c). However, during our few visits we failed to observe this colony, which directly indicates that it often travels to an alternative roosting site, perhaps to avoid predation pressure.

Chiroptera, Hipposideridae
Hipposideros cineraceus Blyth, 1853
(Fig. 3d)

Common name: Ashy Leaf-nosed Bat.

This species occupy the inner chamber of this particular cave and were found to be highly sensitive to human disturbance. Whenever we entered the inner chamber this bat flew away. We confirmed the species by mist net capture.

Carnivora, Viverridae
Viverricula indica Desmarest, 1804

Common Name: Small Indian Civet.

During our routine survey, we observed several pieces of evidences that altogether support that the small Indian civet is a regular visitor for the outer chamber of this cave. Some of the major evidentiary items include: pugmarks near almost every external passage (Fig 3e); scat in various sizes usually found in the outer chamber (Fig 3f); and nail scars (claw marks) on the walls of the cave (Fig 3g). Further the bioinventory records of the park as well as the local tribes' observations also supported the existence of this species in that particular locality. This civet can climb the vertical wall very well, the claw marks on the cave wall as well as unconsumed bat remains directly suggests that it preys upon roosting bats (Fig. 3c).

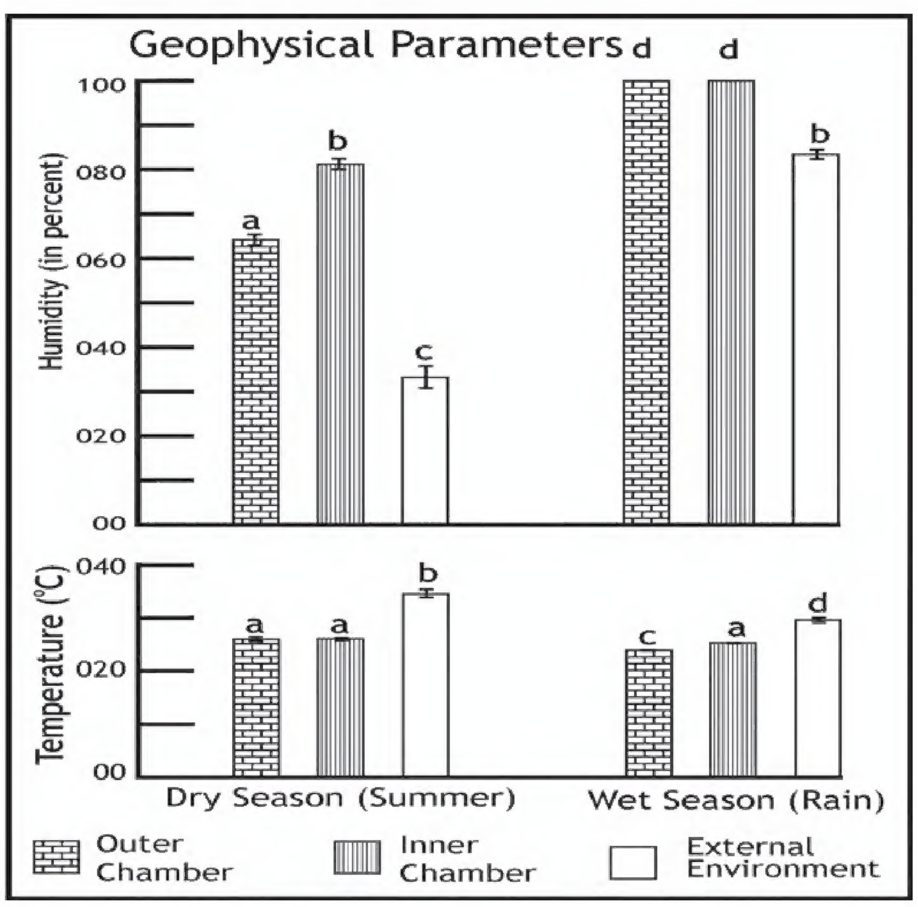

Fig. 2 - Each bar (with its respective standard error) representing mean (air temperature / percentage of water saturation in air; n=5) recorded from three different sites during dry and wet seasons. Results from two way ANOVA (Analysis of Variance) revealed significant season ($p<0.0001$), site ($p<0.0001$), and site X season interaction ($p<0.001$) effects for air temperature. Similarly it also revealed significant season ($p<0.0001$), site ($p<0.0001$) and site X season interaction ($p<0.008$) effects while comparing percent saturation of water in the air (humidity) by two way ANOVA. Further, the histograms bearing similar types of super scripts do not differ statistically from each other at minimum 5% level.

Rodentia, Hystricidae
Hystrix indica Kerr, 1792

Common name: Indian Crested Porcupine.

We counted eighteen possible dens in the inner chamber of this cave of this particular species (Fig 3h). However out of the total number eight were abandoned as evidenced by either being blocked by debris or by being partially collapsed. It is possible that none of these dens are directly connected with the external epigean world. Some well demarcated passages exist in the inner chamber which appears to be used by this porcupine species to enter the chamber. Due to their long term regular use, the walls and floor of these passages have become textured by the quills of these porcupines. Occasionally porcupine dung was also observed, but we had never seen any other organism feeding upon it. The occurrences of quill(s) in the entrance of their passage confirmed its taxonomical status (Fig 3i).

Anura, Ranidae
Hydrophylax malabaricus Tschudi, 1838
(Fig. 3j)

Common name: Fungoid Frog

This frog can be easily seen in the outer chamber of this cave. Its population generally diminished during rain. However, juveniles could be apparent inside the cave from August-September. Cave cricket; *Kempiola shankari* (described later) was observed to be the major prey for it.

Anura, Bufonidae
Duttaphrynus melanostictus Schneider, 1799
(Fig. 3k)

Common name: Black-spined Toad/ Common Indian Toad

A small population of this toad species was always observed during rainy seasons in a particular hidden rocky enclosure of the outer chamber of this cave. Perhaps it remains under torpid conditions in remaining months. Possibly, the abundantly occurring cave cricket is the major food source for this particular species.

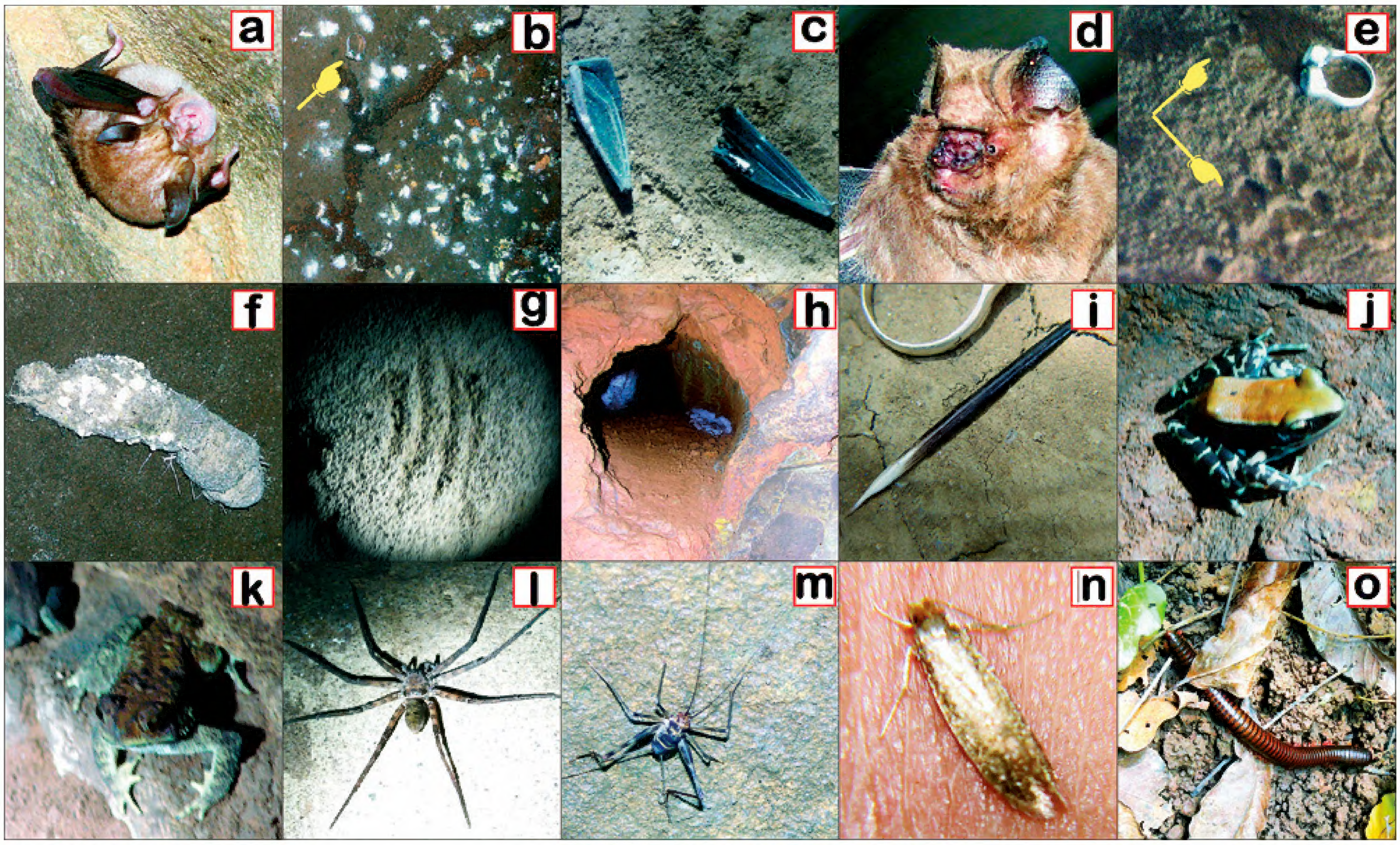

Fig. 3 - Collage of the evidences regarding the animals which generally visits/inhabits the cave. a) *Rhinolophus rouxii* roosting in a wall of the outer chamber. b) decomposing guano piles of *Rhinolophus rouxii* in the floor of outer chamber. c) wings of killed bat *Rhinolophus rouxii* found in the floor of the outer chamber. d) *Hipposideros cineraceus* caught by mist net roost in the inner chamber of the Dandak cave. e) pugmarks of *Viverricula indica* usually seen in the outer chamber. f) decomposing scat (excreta) of *Viverricula indica* in outer chamber of the cave. g) nails' scars of *Viverricula indica* on the walls of the outer chamber of the cave. h) living den of *Hystrix indica* in the inner chamber of the cave. i) quill of *Hystrix indica* found inside one of the den found in the inner chamber of the cave. j) *Hydrophylax malabaricus* always found in the outer chamber. k) *Duttaphrynus melanostictus* apparent during rain in a specific zone in the outer chamber. of the cave. l) *Heteropoda venatoria* usually seen in the outer chamber of the cave. m) *Kempiola shankari* (cave cricket) equally distributed in both the chambers of the Dandak Cave. n) Guano moth; *Kangerosithyris kotumarensis appears* in the inner chamber during rainy season. o) epigean giant millipede often found in the entrance and till some extent in twilight zone of the outer chamber of the cave, possibly play a major role in the cave ecosystem.
*Some images are with a finger ring (b, e & i) i.e., to estimate the sizes.

Table 1 - List of all the observed (direct/indirect) species with their respective habitats (chamber) and cavernicolous status (as per Sket, 2008).

Name of the Species	**Living Status**	**Observed in**	**Observed during**
Rhinolophus rouxii	Subtroglophile	Outer chamber	Round the year
Hipposideros cineraceus	Subtroglophile	Inner Chamber	Round the year
Viverricula indica	Trogloxene (habitual)	Outer chamber	Round the year.
Hystrix indica	Subtroglophile	Inner Chamber	Round the year.
Hydrophylax malabaricus	Subtroglophile	Outer Chamber	Round the year
Duttaphrynus melanostictus	Eutroglophile	Outer Chamber	Rainy season
Heteropoda venatoria	Eutroglophile	Outer Chamber	Round the year
Kempiola shankari	Eutroglophile	Both the Chambers	Round the Year
Kangerosithyris kotumarensis	Troglobite	Inner Chamber	Rainy Season
Giant millipede	Trogloxene (accidental)	Outer chamber	Round the year

Invertebrates:

Araneae, Sparassidae/Heteropodinae
Heteropoda venatoria Linnaeus, 1767
(Fig. 3l)

Common name: Giant crab spider or the banana spider.

Throughout the year juveniles and adults, both of this species can be easily seen in every nook and corner of the outer chamber of this cave. It has prominent eyes but generally remains unaffected from torch lights, as their eyes reflect light (Wallace 1937; Biswas 2010). This species seems a little sluggish in nature and inhabit the cave in search of easily available prey.

Orthoptera, Gryllidae/Phalangopsidae
Kempiola shankari Sinha and Agarwal, 1977
(Fig. 3m)

Common name: Cave cricket.

It is the only species that can be easily observed directly from the entrance gate of the outer chamber through the deeper zones of the inner chamber of the Dandak cave. It is the most abundantly occurring species in this cave. The species is highly endemic for the caves of this specific zone (Biswas 2010). The insect has been observed to reproduce throughout the year and all developmental stages can be easily found inside the cave.

Lepidoptera, Tineidae
Kangerosithyris kotumarensis Skalski, 1992
(Fig. 3n)

Common name: Guano-moth

Like *Kempiola shankari* this moth is also highly endemic for the caves of Kanger valley national park (Biswas 2010). It is guanophilic moth, only apparent during wet season when humidity is 100%. It occurs only around the guano deposits in the inner chamber of this cave. It rarely flies, usually moves in short leaps. It is truly cave adapted and never responds to light (Skalski 1992; Biswas 2010).

Few arthropods such as isopods acari, ants etc. were often seen in both the chambers of this cave. Since we failed to record any permanent population(s) of these animals we did not tabulate them as an inhabitant of this cave. Possibly they represent the accidental trogloxene categories which have been entered into the cave via air current, with certain habitual trogloxene or by flood during rain. However, we frequently observed a giant millipede in the outer ecotone zone of this cave, which sometimes often enters far end of the twilight zone of this cave. Perhaps, this millipede plays a role on the ecosystem of the outer chamber, thus we have tabulated it under the category of accidental trogloxene.

DISCUSSION

To date not a single mammal is reported as permanently cave adapted, though these animals regularly use the subterranean caves to somehow meet their biological requirements. In fact, caves offer a wide spectrum of microhabitats (Ginet and Decou 1977) which attract several animals either for resting, mating, nesting or hibernating. Nevertheless, easy availability of prey also attracts various nocturnal and even diurnal animals to caves. Though the Dandak cave as a whole represents a single identity, its two chambers represent two nearly distinct ecosystems and offer two completely diversified habitats. The outer chamber remains highly influenced by the epigean environmental conditions and thus its complete ecosystem also seems to be regulated by the external environmental conditions. Conversely the inner chamber is like a sealed enclave being far less influenced by the external world (Fig. 2).

In our study we found *Viverricola indica* as the dominant mammal, a regular visitor for the outer chamber of the cave. Observed evidence directly suggests that it comes in the outer chamber of this cave to hunt the roosting bat; *Rhinolophus rouxii*. Additionally, crickets, spiders, millipedes and amphibians are also known to be the favorable prey for this particular civet (Ayyadurai et al 1987; Chuang and Lee 1997; Mallick 2006) which are always available in the outer chamber of the this cave. Perhaps it is the first record suggesting that, the civet is at the topmost level of an ecological food pyramid for any cave. However, as per the notes of Kemp (1924) on the mammals of the Siju Cave of Meghalaya, India it could be speculated that the small cat (*Felis* sp.) which was a regular visitor of Siju cave prey upon the rat; *Ratus nitudus nitidus* which was very common in that cave.

Ringtail (*Bassariscus astustus),* red fox (*Vulpes vulpes)*, coyote (*Canis latrans)*, badger (*Meles meles)* and striped shunk *(Mephtis mephtis)* are some of the reported mammals that usually visit the temperate caves in search of young bat or birds as prey (Tvrtkovic̆ 2005). As per Juberthie et al (1998) the temperate cave bats usually become victim during their hibernation. Occasionally various carnivores have been reported from tropical caves either in search of prey or to meet some other biological requirements (Gunn 2004, Harries et al 2008).

Porcupines use subterranean caves for their diurnal resting phase were already reported from several parts of the world (Price 2004; Moseley 2007; Harries et al 2009). In the inner chamber of the Dandak cave most of the dens are found as blind pockets, where this species remain during their resting phase. However, we speculate that in addition to the day-time resting and/or escaping predation pressure, the abundantly occurring cricket (as prey) and the water channels which feed seepage water throughout the year are some of the additional factors

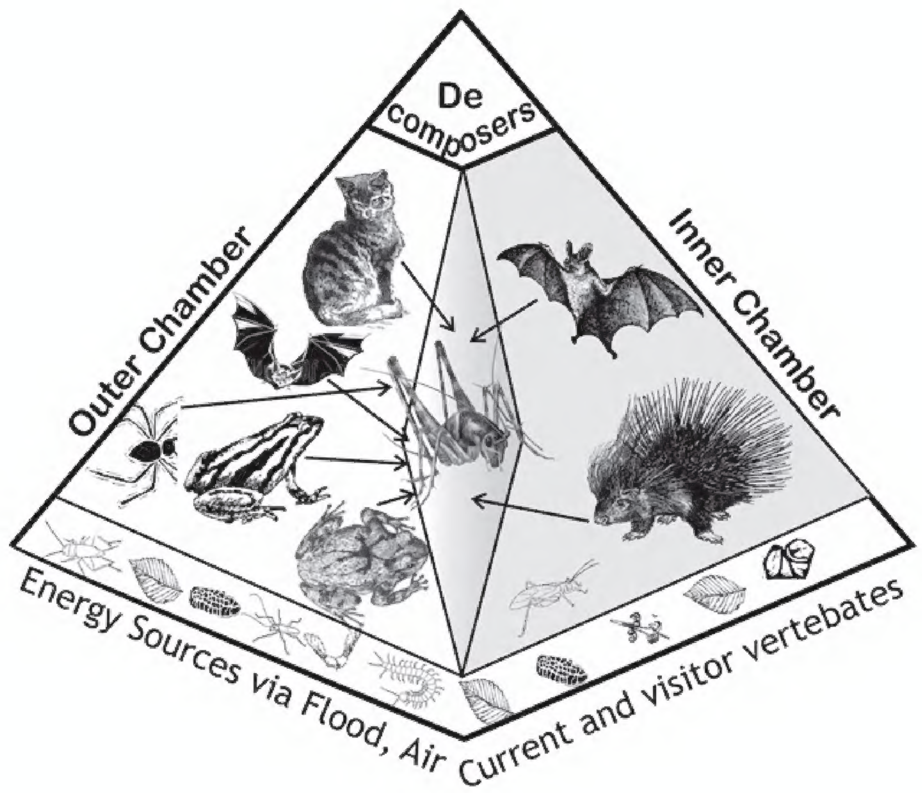

Fig. 4 - Ecological food pyramid, possibly operating inside the Dandak cave.

that altogether attracting the porcupine *Hystrix indica* to inhabit this cave.

The cricket, *Kempiola shankari* is the most abundantly occurring species appearing to be equally distributed in both the chambers of this cave. This species plays the key role in binding the complete ecosystem of this cave together. Two distinct insectivorous bats; *Rhinolophus rouxii* and *Hipposideros cineraceus* occupying two different chambers of this cave definitely prey upon this particular cricket. Further, two anurans; *Hydrophulax malabaricus* and *Duttaphrynus melanostictus* inhabit the outer chamber of this cave and also prefer cricket as their food. Indian (Crested) Porcupines which have been found to be a regular visitor to the inner chamber of this cave were also reported to feed occasionally on insects and small mammals (Kadhim 1997) which directly suggests that this cricket often become the victim of the porcupine. It has also been reported that in cave ecosystems giant *Heteropoda* sps. also feed upon the cave crickets (Harries et al 2009).

Microchiropterans are always the major energy source importer for any subterranean cave ultimately playing a major role in its ecosystem. The bat guano deposits are usually able to maintain a complete ecosystem in itself. However, in Dandak cave, bat droppings are found to be of incidental importance in the ecosystem. In both the chambers bat droppings were observed to be very haphazardly distributed on the floor and never forming substantial guano deposits which can support a guanophilic community. We speculated that the high predation pressure forced them to alter their roosting sites in a regular fashion. Though the predation pressure is less in the inner chamber and the abiotic factors are also relatively constant and distinct, a true cave adapted guanophilic species; *Kangerosithyris kotumarensis* was observed here as is common to the nearby cave "Kotumsar" (Biswas 2010).

Fossil records testify that the *Viverricula indica* as well as *Hystrix indica* were inhabitant of Asian caves even during Late Pleistocene-Holocene age (Ghosh 1991; Patnaik et al 2008; Mashkour et al 2009). However, the speculations regarding their existence in the caves were restricted to the idea that these species used the cave as a day resting phase or shelter. Our study directly suggests that both of these mammals play a major role on the complete ecosystem of the Dandak cave. Inspite of taking meager shelter these species are also getting easily available prey inside the respective chambers of occurrence of this cave. Conclusively, the two chambers of the Dandak cave possess two separate habitats, thus the ecological process operating inside each chamber are highly different from each other. The cricket; *Kempiola shankari* is the only factor found common for both the chamber which in fact is the most fascinating species to bind the complete ecosystem together (Fig. 4).

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